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Technical Memorandum

ACSAS INTENTIONS FOR TETHERED ACOUSTIC TESTS

DATE: 2 October 1984

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The intentions of the ACSAS Project with regard to the tethered acoustic tests at Pend Oreille (Idaho) during the summer of 1984 are outlined. Identical measurements to be made on two different arrays installed on KAMLOOPS (ALT I and ALT III) are described. A somewhat different set of measurements to be made on a third array (ALT?? IV), later installed on the same quarter-scale model are described in an Addendum.

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ABSTRACT

The intentions of the ACSAS Project with regard to the tethered acoustic tests at Pend Oreille (Idaho) during the summer of 1984 are outlined. Identical measurements to be made on two different arrays installed on KAMLOOPS (ALT I and ALT III) are described. A somewhat different set of measurements to be made on a third array (ALT IV), later installed on the same quarter-scale model are described in an Addendum.

The geometry for the proposed ACSAS Tethered Acoustic Tests is indicated below in Figure 1.

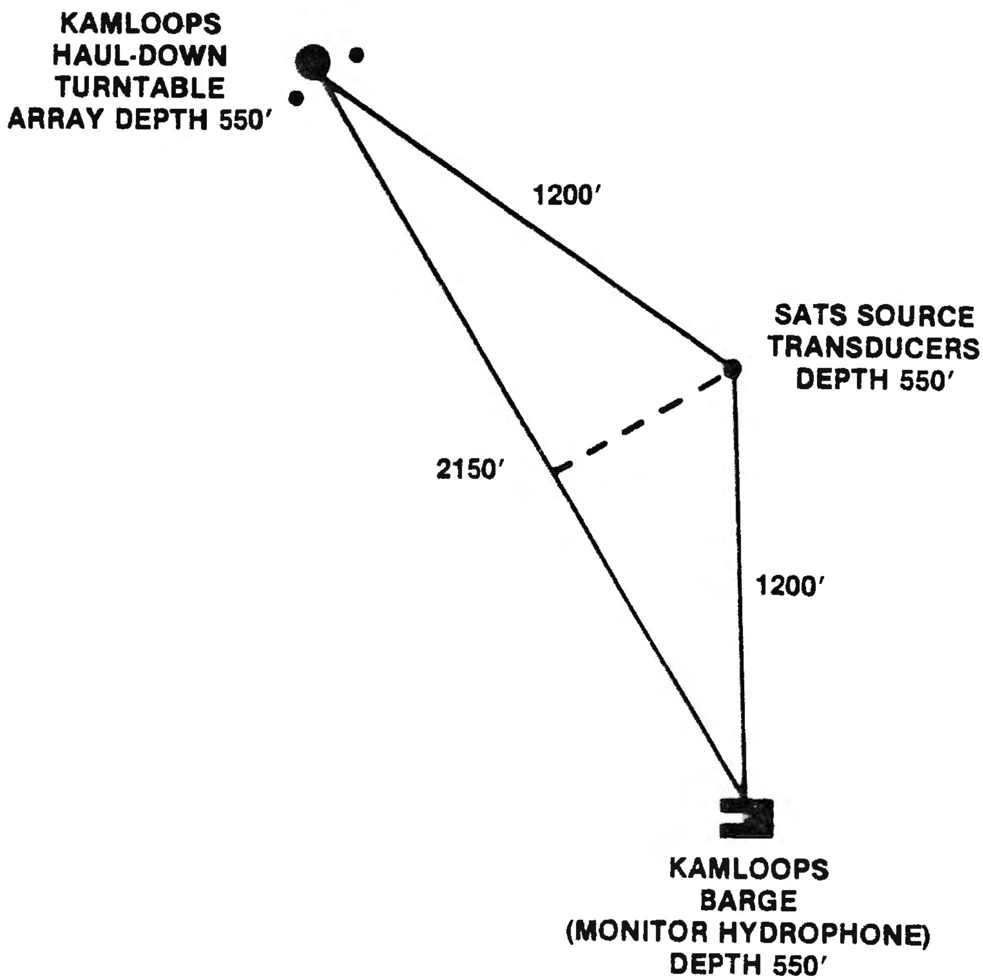
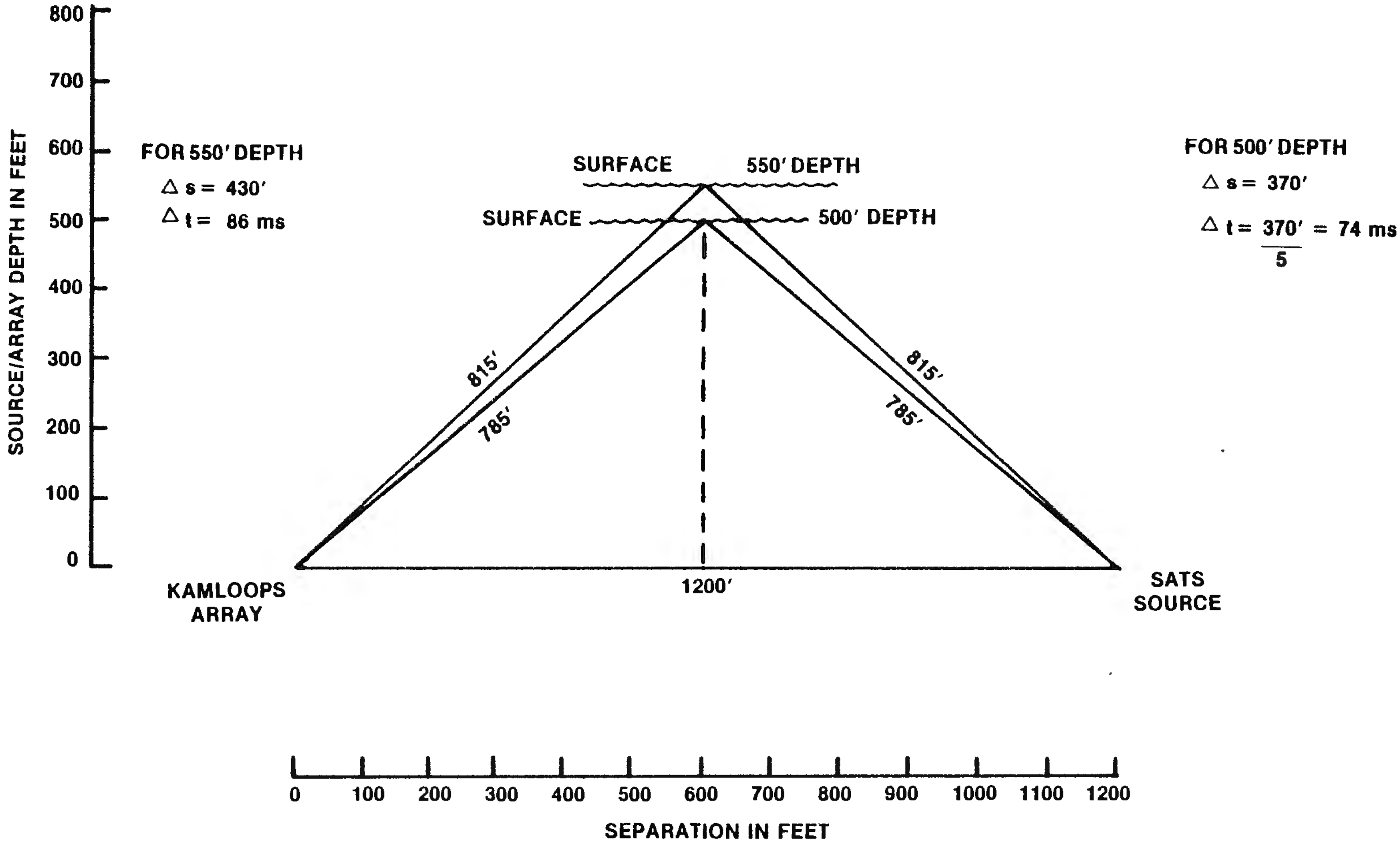


Figure 1

A time separation between the direct path and the surface reflection is expected to be approximately 86 ms based on a depth of 550' for both KAMLOOPS and for the SATS Array as shown in the following Figure 2.



SOURCE/ARRAY DEPTH IN FEET
800
700
600
500
400
300
200
100
0
FOR 550' DEPTH
△ s = 430'
△ t = 86 ms
SURFACE
550' DEPTH
SURFACE
500' DEPTH
FOR 500' DEPTH
△ s = 370'
△ t = 370' / 5 = 74 ms
815'
785'
815'
785'
KAMLOOPS ARRAY
1200'
SATS SOURCE
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
SEPARATION IN FEET

Figure 2

An arm will be mounted on KAMLOOPS with a hydrophone at each end to be used for orienting KAMLOOPS.

The arm will be mounted so as to be normal to the plane of the KAMLOOPS midline as shown below in Figure 3.

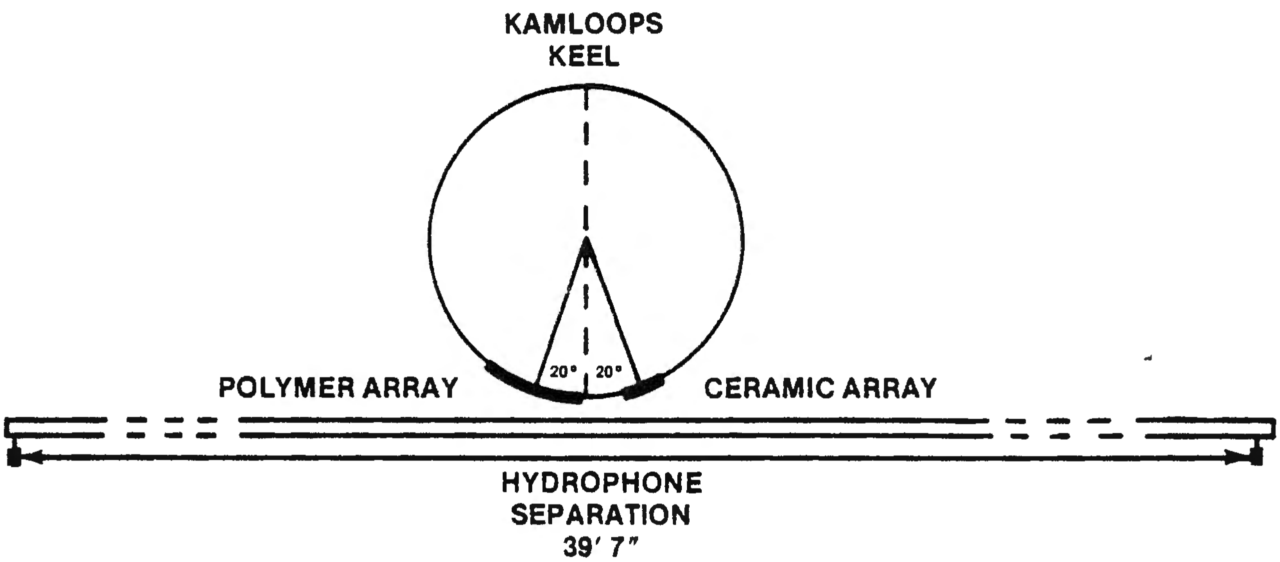


Figure 3

Time differences between the two arm hydrophones will depend upon the sound speed (taken to be 4681.7 ft/sec at 550') and the angle of rotation of the arm.

The time differences will be read directly (live) off an oscilloscope on the barge; arrival times will also be recorded on the digital system.

The sense of rotations for angles referred to each of the arrays is indicated in Figure 4.

The angles to be used during the first phase of the tethered acoustic tests (pulsed sine wave transmissions) are listed in Table 1, as well as the corresponding travel times.

KAMLOOPS suspended BOW UP

Polymer hydrophones center to center spacing = 2.56" 11 x 11 array is 28.1" long subtended angle = 37.4^0
Ceramic hydrophones center to center spacing = 0.5 11 x 11 array is 5.5" long subtended angle = 7.35^0

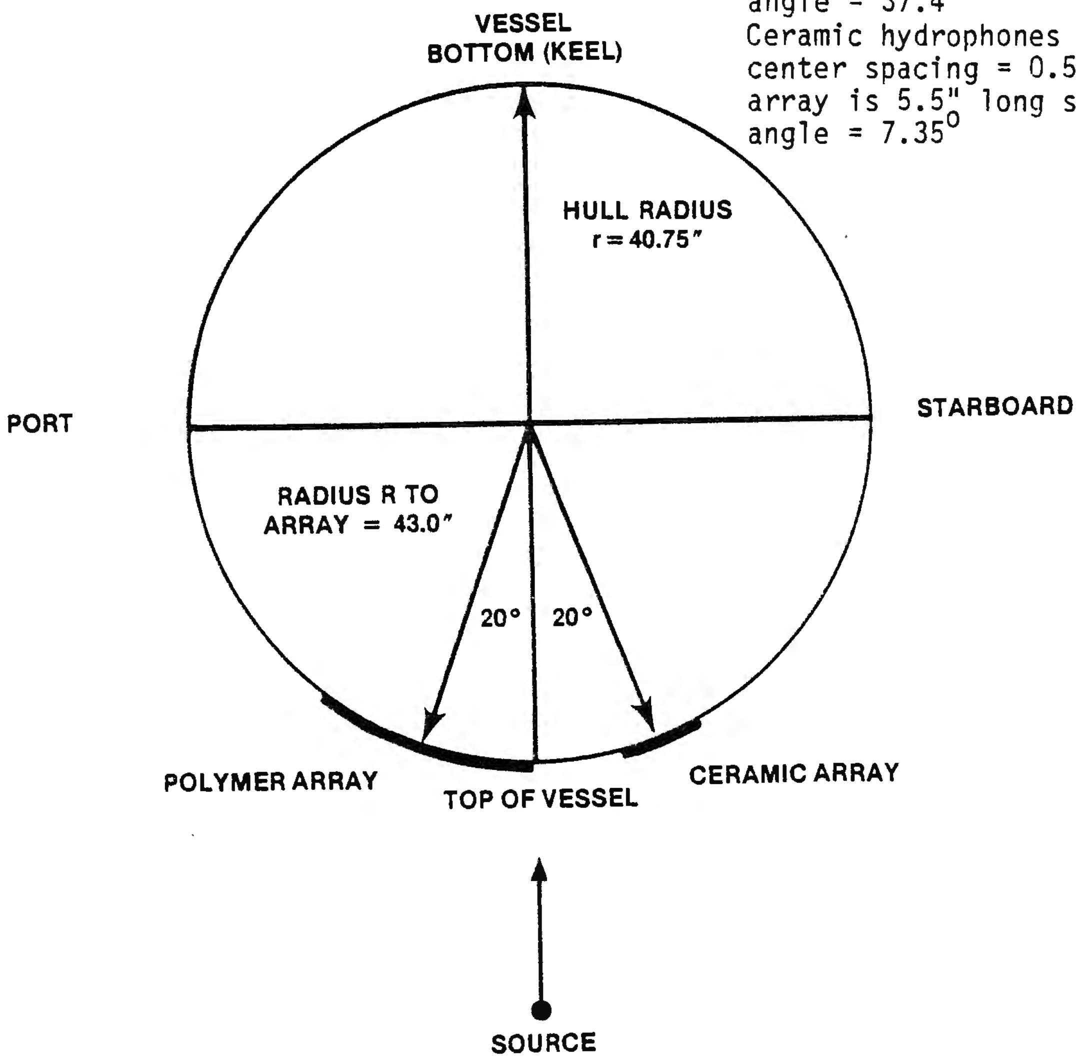


Figure 4

So, a transmission which is "Grazing" to the center of the Polymer Array means that the model must be rotated 70^0 to the port. (That is, the port hydrophone will be even farther away)

A "Broadside" transmission to Polymer Array requires the model to be rotated 20^0 to starboard

A transmission which is Grazing at the center of the Ceramic Array requires that the model be rotated 70^0 to the starboard (That is, the starboard hydrophone will be even farther away than usual)

A "Broadside" transmission to the Ceramic Array requires the model to be rotated 20^0 to port

Stationary Noise Pulsing	Angle to which the model and hydrophone arm must be rotated from the broadside position of hydrophone arm	Time Difference in Milliseconds between the two arm hydrophones	Which Arm hydrophone should receive signal first	Equivalent angle with reference to broadside on polymer array	Equivalent angle with reference to broadside on ceramic array
	To Starboard		Port Hyd		
	90°	8.46	"	70°	110°
Noise Pulses	70°*	7.95	"	50°	Grazing 90°
Noise Pulses	20°*	2.89	"	Broadside 0°	40°
	To Port		Starboard		
	16°	2.33	"	36°	4°
	18°	2.61	"	38°	2°
Noise Pulses	20°	2.89	"	40°	Broadside 0°
	66°	7.72	"	86°	46°
	68°	7.84	"	88°	48°
Noise Pulses	70°	7.95	"	Grazing 90°	50°
	90°	8.46	"	110°	70°
Noise Pulses	160°*	2.89	"	180°	140°

Note: Grazing here means grazing at the central element of the array in question.

There will be pulsed sine wave signals at each of the above listed angles, and pulsed noise (400-4000Hz) signal transmissions at the five angles so specified above.

NSRDC personnel will make analog recordings at those bearings marked with a * and at arm hydrophone angles of 000° (broadside for the arm hydrophones) and 135° to port (Geib Array)

Table 1

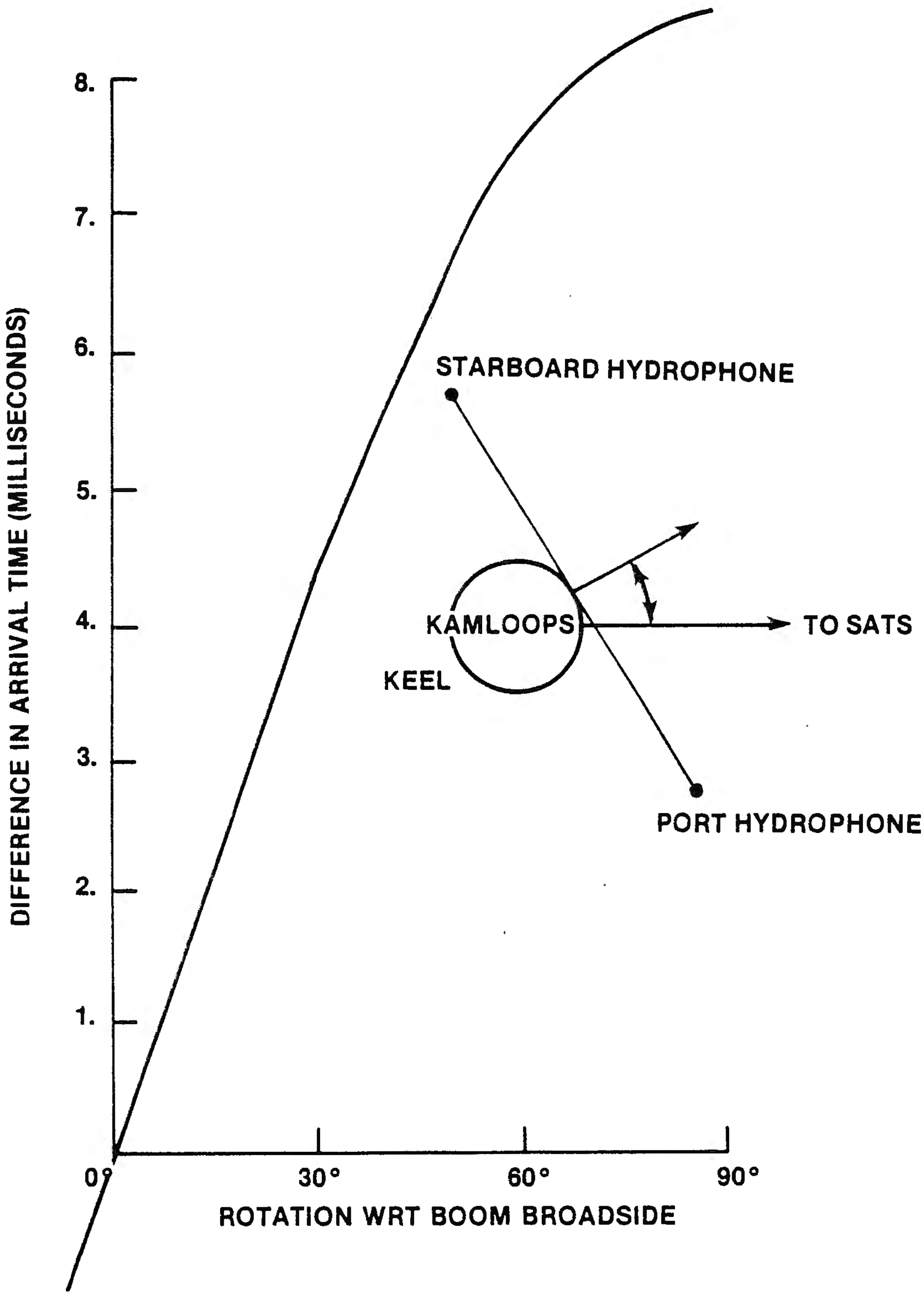


Figure 5

A curve for readily determining other angles is included here as Figure 5.

Pulsed Sine Wave Signal Tests

The pulsed sine wave tests will be the first of the series undertaken.

It is expected that at each of the specified bearings short, non-shaped pulses at 4000 Hz will be transmitted to the arm hydrophones at a repetition rate of 1 pulse/second for purposes of setting the model at the proper rotation angle.

Once the model has settled to a satisfactory bearing angle, the data acquisition with Gaussian-shaped pulsed sine wave signals can commence.

Two frequencies will be transmitted simultaneously and those frequencies are listed in Tables 2 and 3. There are a total of 92 frequencies to be transmitted. One set of 46 frequencies transmitted through one amplifier and (low-frequency) transducer and the other set of 46 frequencies to be transmitted through a separate amplifier and (high frequency) transducer simultaneously.

Voltage levels for each frequency are also listed as peak--to-peak values in millivolts.

Gaussian shaped pulses at the proper frequencies and levels will be generated on the VAX and injected into the SATS amplifiers. Triggering and windowing will also be generated on the VAX.

It will not be possible to perform a VAX Calibration, or Test, or to obtain an Ambient sample during the data acquisition period due to constraints imposed by the digital system.

It will be possible however to record Calibration, Test and Ambient on separate tapes, before or after each data acquisition peiod. The current intent is to record Cal. (at a gain of 0), Test and Ambient (at a gain of 24 dB) at the beginning and end of each day's experiment, and at such other times that significant changes have occurred.

It is estimated (prior to test time) that a step-gain of* 24 dB will be suitable for all polymer and ceramic elements during the pulsed sine-wave tests (More gain may be desirable during pulsed noise tests).

Initial step-gains of 0 dB on sine wave pulses and 36 dB on noise pulses will be used for the point hydrophones and for both large and small omni hydrophones.

Pulse repetitions interval = 500 ms
Gate length = 100 ms
Total Pulse Width = 100 ms
Pulse Width at 6 dB down points = 40 ms.

Note that a repetition interval of 500 ms permits us to go through all 45 (x2) frequencies in 500 x 46 = 23000 ms, while the data record length (with windowing and packing) will still be less than 5 seconds.

*In actual practice rarely was it necessary or desirable to use any step gain greater than 12 dB for either pulsed sine wave or pulsed noise transmissions.

List of Frequencies/Voltages/Received Levels

No.	Freq.	SATS Drive Level Milli-volts Pk-Pk	Monitor Hydrophone Scope Reading in Volts RMS	No.	Freq.	SATS Drive Level Milli-volts Pk-Pk	Monitor Hydrophone Scope Reading in Volts RMS
1	1480	800	.085	31	840	471	.0785
2	1520	1000	"	32	880	529	"
3	1560	1100	"	33	920	593	"
4	1600	1300	"	34	960	704	"
5	1640	2000	.0785	35	1000	746	"
6	1680	1900	.0785	36	1040	790	"
7	1720	1760	.085	38	1120	940	.091
8	1760	1900	.085	39	1160	1030	.085
9	1800	1400	.0707	40	1200	1054	"
10	1840	1400	.085"	41	1240	1000	"
11	1880	1400	"	42	1280	1000	"
12	1420	1400	"	43	1320	1000	"
13	1960	1400	"	44	1360	800	"
14	2000	1400	.091	45	1400	800	"
15	2040	1400	.091	46	1440	900	"
16	2080	1000	.0785				
17	2120	1000	.085				
18	2160	1000	.085				
19	2200	800	.091				
20	400	3333	.085				
21	440	3155	.0785				
22	480	2907	.085				
23	520	2591	"				
24	560	1876	"				
25	600	1527	"				
26	640	1185	"				
27	680	838	.091				
28	720	593	.085				
29	760	471	.085				
30	800	420	.0785				

Table 2

List of Frequencies/Voltages/Received Levels

No.	Freq.	SATS Drive Level Milli-volts Pk-Pk	Monitor Hydrophone Scope Reading in Volts RMS
1	2200	3400	.0785
2	2240	3400	"
3	2280	3400	"
4	2320	"	"
5	2360	"	"
6	2400	"	.0850
7	2440	"	.0910
8	2480	"	.0785
9	2520	3000	.0850
10	2560	"	"
11	2600	"	"
12	2640	"	"
13	2680	"	"
14	2720	"	"
15	2760	"	"
16	2800	2500	"
17	2840	"	"
18	2880	"	"
19	2920	"	"
20	2960	"	"
21	3000	"	"
22	3040	"	"
23	3080	"	"
24	3120	"	"
25	3160	"	.0785
26	3200	"	.0850
27	3240	"	"
28	3280	"	"
29	2320	"	"
30	3360	2000	.0785
31	3400	"	"
32	3440	"	"
33	3480	"	"
34	3520	"	"
35	3560	"	.0850
36	3600	2000	.0850
37	3640	"	"
38	3680	"	"
39	3720	1800	"
40	3760	"	"
41	3800	"	"
42	3840	"	"
43	3880	1600	"
44	3920	"	"
45	3960	"	"
46	4000	"	"

Table 3

The time to tramsfer the 5 seconds of data to the VAX is 20 minutes and another 20 minutes will be required to transfer the data from VAX disk to a backup (image) tape. The total data transfer time at each bearing then will be 40 minutes, and the total time for all eleven angles listed will be 7 hours plus time for calibration, test and ambient recording (30 minutes?) and for quick look determinations of the quality of results (1.5 hours?)

An additional 30 minutes to an hour may be required for angle determinations prior to data recording at each angle.

The total accountable time will be something like 9 1/2 to 10 hours and 12 hours should not surprise anyone.

Pulsed Noise Tests

Gaussian shaped noise pulses will be generated on the SATS. Again however, during these pulsed noise tests we will be able to take advantage of the data "packing" on the HSRS disk afforded by the windowing provided by the VAX program. To provide that windowing, the VAX must also provide the trigger to SATS.

Then, Pulse repetition interval = 1 pulse/second
Gate length = 93 ms
Total Gaussian shaped pulse length = 80 ms
Pulse width at 6 dB downpoints = 35 ms

Note: Window length must be in certain specified increments only so we are forced to use 93 ms to keep the signal in the window.

The requirement has been expressed for 60 pulses per angular position. Therefore, we have 60 x 93 ms = 5580 ms for a total HSRS record length at each angle.

Again it will require approximately 20 minutes to transfer the data from HSRS to VAX and 20 minutes to transfer the data from the VAX to tape for a total of 40 minutes data transfer time per angular position.

The time then to acquire the data set at all of the 5 angles indicated will be approximately 3 1/2 hours plus time for calibration, test and ambient recording (30 minutes), for angle determinations (30 minutes to an hour) and time for NSRDC analog recordings (30 minutes?)

The total accountable time for the fixed angular position pulsed noise measurements will be 5 1/2 to 6 hours which could easily run to 8 or 9 hours depending on the time spent on quick look procedures.

Consideration of a pulsed noise continuous rotation event has been dropped due to the general conclusion that such a measurement is not feasible in the time available. Instead, a measurement of noise pulses transmitted at one degree angular intervals will be made

Noise Pulses at One Degree Intervals

The intent is to do this evaluation with broad-band noise pulses providing there is adequate S/N across the band. If not, after looking at a spectral plot, then pulsed sine wave signals will be substituted.

The proposed plan is to transmit pulses at a set of 1-degree intervals about each of 3 "primary" angles on the polymer array. These three primary angles are:

40° off Broadside to Polymer Array (Broadside to the Ceramic Array)
90° (Grazing to central element of the Polymer Array)
0° (Broadside to the Polymer Array)

During this experiment only three transmitters will be used (in order to reduce the data transfer time required). The transmitters used will be:

Xmtr #4 - 24 elements from the polymer array
Xmtr #7 - 24 elements from the ceramic array
Xmtr #12 - both "arm hydrophones"
Channel #14 - port hydrophone
Channel #13 - starboard hydrophone
and the gyro (bearing) output as well.

Data transfer times for an 11-second data record for only three transmitter cans will be approximately 10 minutes for transferring data from the HSRS to the VAX and 10 minutes for transferring the data from VAX to tape. The total time to transfer data after each transmission angle would be approximately 20 minutes for an 11-second data record.

For nine angles at each of the primary angles listed above including the primary angle and 4 degrees on each side of the primary angle the total data transfer time would be then 180 minutes or approximately 3 hours.

To conduct the requested measurements at all 3 primary angles will take something in excess of 9 hours.

The angles desired are listed in Table 4, along with arm hydrophone time differences and corresponding angles referred to broadside for the polymer array.

It is also requested that there be recorded 60 pulses at each angle (if noise pulses are used).

If it should be necessary to use pulsed sine-wave signals due to S/N problems only one pulse/frequency/angle will be required.

It is assumed here, however, that noise pulses will be satisfactory and once again Gaussian shaped noise pulses will be generated on the SATS equipment.

Gating and windowing will be generated on the VAX.

Angle to which Hydrophone Arm must be Rotated from the Broadside Position of the Hydrophone Arm	Time in Milliseconds between the two Arm Hydrophone	Which Hydrophone should see the Signal First	Equivalent Angle with reference to Broadside on Polymer Array	Recorded Tape numbers for Sept 1984 Tethered Acoustic Tests
To Starboard				
24°	3.44	Port Hyd	04°	A56
22°	3.17	" "	02°	A55
Priority 3 20°	2.89	" "	Broadside 0°	A54
18°	2.61	" "	02°	A53
16°	2.33	" "	04°	A52
To Port				
16°	2.33	Starboard Hyd	36°	A32
17°	2.47	" "	37°	A33
18°	2.61	" "	38°	A34
19°	2.75	" "	39°	A35
Priority 1 20°	2.89	" "	40°	A37
21°	3.03	" "	41°	A39
22°	3.17	" "	42°	A40
23°	3.30	" "	43°	A41
24°	3.44	" "	44°	A42
66°	7.72	" "	86°	A43
67°	7.78	" "	87°	A44
68°	7.84	" "	88°	A45
69°	7.89	" "	89°	A46
Priority 2 70°	7.95	" "	Grazing 90°	A47
71°	7.99	" "	91°	A48
72°	8.04	" "	92°	A49
73°	8.09	" "	93°	A50
74°	8.13	" "	94°	A51

Table 4

Gate Length: 80 ms: Pulse Repetition Interval: 1 pulse/second
Total Gaussian Shaped Pulse Length: 80 ms
Pulse width at 6 dB downpoints: 35 ms

If we transmit 60 pulses at each angle, then we have 60 x 80 = 4800 ms total HSRS record length at each angle. This data would be acquired in one minute for a total recording time of 27 minutes (i.e., 27 angles)

As noted earlier, the total data transfer time for 11 seconds of data at each angle would be 9 hours. However, recording for only 5 seconds at each angle will reduce this by half, so that the total expected time required for data transfer will be 4.5 hours.

The estimated measurement time for this event would be 4.5 hours plus 0.5 hour for recording time, plus an estimated 5 hours for setting angles, plus 0.5 hour for calibration test and ambient recording and 2 hours for quick-look suggests a total time for this event of approximately 12.5 hours.

ALT 4 ADDENDUM TO ACSAS INTENTIONS FOR TETHERED ACOUSTIC TESTS

During ALT 4 tethered acoustic tests, the intent is to run the sine wave tethered pulsed data as described earlier and generally as previously performed.

One change will be made to all phases of the ALT 4 tests:Pulse intervals will all be increased to 1.5 seconds.

It is expected that there will be four days of testing.

Grazing and Boresight	Day 1	Pulsed Sine Wave Signals		10 Angles
Selected Angles	Day 2	Pulsed Noise	60 Pulses/Angle	5 Angles
Grazing Angles	Day 3	Pulsed Noise	60 Pulses/Angle	10 Angles
Array Boresight	Day 4	Pulsed Noise	60 Pulses/Angle	14 Angles

For Pulsed Sine Wave Signals

Pulse Repetition Interval = 1.5 Seconds
Gate Length (nominally 100 ms) = 93 ms
Total Pulse Length (nominally 100 ms) = 93 ms
Pulse length at 6 dB Down Points = 40 ms

For Pulsed Gaussian Shaped Noise Pulses

Pulse Repetition Interval = 1.5 seconds
Gate Length (nominally 100 ms = 93 ms)
Total Pulse Length = 80 ms
Pulse Length at 6 dB Down Points = 35 ms

The angles desired for each test are listed on the attached pages.

For the pulsed sine wave signals 92 frequencies will be transmitted (in 46 pairs) at each angle. A given frequency will be transmitted only once at each angle.

All eight transmitter cans will be required for each transmission, so the data recovery time at each angle will be approximately 15 minutes and the time required to make a backup (image) tape at each angle will also be 15 minutes. If we allow 15 minutes quick look time on the average and 15 minutes (roughly) to arrive at the proper angle after each rotation, the total time per angle should be on the order of 1 hour. That is, each test day will be on the order of 10 to 14 hours plus time for calibrations and ambient measurements (perhaps another 45 minutes)

Bearings and Time Delays for ALT 4 Acoustic Tethered Tests

For Test Days #1 and #2

Angle to which the Model and Hydrophone Arm must be Rotated from the Broadside Position of Hydrophone Arm	Time Difference in Milliseconds Between the Two Arm Hydrophones	Which Arm Hydrophone Should Receive Signal First	Angles Selected for Noise Pulsing	Specific Interest in Angle in Question
To Starboard				
180.0°	0000	Neither	Noise Pulses	Backside of Array
111.11°	7.89	Port	Noise Pulses	Tangent to Center of Port (Good) Array Half
090.0°	8.45	"	Noise Pulses	Tangent to Center of Array
038.7°	5.29	"		Normal to Port Edge of Array (Col.1)
031.6°	4.43	"		Normal to Column 2 of Array
024.6°	3.52	"		Normal to Column 3 of Array
021.1°	3.04	"	Noise Pulses	Normal to Center of Port (Good) Array Half
000°	0000	Neither	Noise Pulses	Normal to Center of Array
To Port		Starboard		
021.1°	3.04	"		Normal to Center of Stbd. Array Half
038.7°	5.29	"		Normal to Stbd Edge of Array (Col. 12)

Table 5

It is expected that NSRDC representatives will make analog recordings at some of the above angles, and at one or two other angles to be identified.

There will be pulsed sine wave signal transmissions at each of the above listed angles, and pulsed noise (400-4000 Hz) signal transmissions at each of the five angles so indicated (Noise Pulses) above.

Test Day #1 will consist of the above pulsed sine wave measurements.

Test Day #2 will consist of the above indicated pulsed noise measurements.

Test Day #3, 4 and 5 will consist of pulsed noise measurements at close angular spacings (approximately 1°) using a small set (3 or 4) of transmitter cans).

ALT 4 Acoustic Tethered Tests
Close-Angle Bearings

For Test Day #3

Angle to which the Model and Hydrophone Arm Must be Rotated from the Broadside Position All Angles Below Are to the Port	Time Difference in Milliseconds Between The Two Arm Hydrophones	Which Arm Hydrophone should see The Signal First	Why These Angles
111.1° to Port	7.89	Starboard Hydrophone	Grazing to Port Subarray
108	8.04		
106	8.13		
104	8.20		
100	8.33		
96	8.41		
90	8.46		Grazing to Port Subarray
83	8.39		
80	8.33		
76	8.20		

Table 6

Test Day #4

Angle to Which the Model and Hydrophone Arm Must be Rotated From the Broadside Position	Time Difference in Milliseconds The Two Arm Hydrophones	Which Arm Hydrophone Should See the First	Why These Angles?
10^{o} To Port	1.47	Starboard Hyd.	Beauty
9^{o}	1.32		
8^{o}	1.18		
7^{o}	1.03		
6^{o}	0.88		
5^{o}	0.74		Truth
4^{o}	0.59		
3^{o}	0.44		
2^{o}	0.30		
1^{o}	0.15		
0^{o}	0.00		Boresight Total Array
2^{o} To Starboard	0.30	Port Hydrophone	Symmetry Check
4^{o}	0.59		
6^{o}	0.88		

Table 7

ACSAS INTENTIONS FOR TETHERED ACOUSTIC TESTS
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